Advanced Distribution Management Systems: The Foundation of Distribution System Operations

by Izabela Stefani and Luka Strezoski

Executive summary

High penetration of distributed energy resources and the increasingly dynamic nature of distribution systems creates many new challenges for today's distribution system operators. To cope with these tremendous changes, they need to take an active role in managing their systems and adapt to varying conditions in real time. Only a comprehensive set of specialized software tools integrated into a robust solution can handle these challenges and ensure a smooth transition – from traditional, paper-driven processes to a digital and adaptive way of managing grids in real-time. These capabilities are now offered through an Advanced Distribution Management System (ADMS).

Distribution network evolution

From a traditional electric distribution system to renewables and electric vehicles

The traditional way of producing electric power and supplying it to end customers was straightforward. The electricity was produced in bulk via large power plants, transmitted through high voltage lines to the supply stations, and then through distribution lines, distributed to consumers. Power flow at the distribution system level was in a top down, one-way direction with voltage dropping along the feeders due to natural energy losses. Traditional voltage regulating devices (voltage regulators, capacitor banks, etc.) were strategically located at predefined positions and helped maintain voltage inside regulatory boundaries. Protection equipment was traditionally located at predefined critical locations and set to react on unidirectional fault currents (from the supply station to the fault location). Distribution protection, control, and metering were handled by electromechanical devices, and almost no automation existed at the traditional distribution system level. Consequently, Distribution Network Operators (DNOs) at that time could manage their grids manually, applying traditional paper-driven processes.

Today's challenges

Today, a huge paradigm shift is shaking traditional distribution systems operations: rapidly increasing deployment of Distributed Energy Resources (DER). The proliferation of DER use is being driven by low-carbon initiatives introduced around the world, greenhouse gas emissions from coal power plants and gas-fueled vehicles, and the plummeting cost of DER such as solar photovoltaics (PV), wind energy storage and electric vehicles (EV).

Because output from renewable DER are variable by nature, and time and location of electric vehicle charging is difficult to predict, these new resources introduce a high level of uncertainty and variability into the operation of distribution networks.

Optimal coordination of these new resources ensuring reliable grid integration and operation is still in its infancy. But recent initiatives in grid automation and modernization, applied by the integration of remotely controlled regulation, protection and metering devices, provides better situational awareness with the ability to monitor and control a growing number of interconnected distribution grid assets.

Nonetheless, to defer the expense of retrofitting distribution circuits, they are being loaded more heavily, closer to their limits. This additionally complicates traditional switching procedures, as operators can no longer count on having spare capacity on adjacent circuits for performing load transfers that help satisfy various operating objectives.

Finally, outages caused by some of the most serious storms witnessed in recent history have left catastrophic consequences to electric infrastructures that are unprepared and unequipped for such threats.

To bridge the gap between traditional practices for managing distribution networks and new practices required to address these challenges, as well as to have greater visibility and control and ultimately optimize grid-connected assets for reliability and economic objectives, traditional DNOs are shifting toward a role involving more complex operations, called Distribution System Operators (DSOs).

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DSO responsibilities

DSOs must provide:

1. Reliable and affordable grid operations:

- Ensure the grid operates within technical and operational limits providing reliable electricity to customers
- Enable the grid to be more resilient under circuit trips and generation loss
- Coordinate with Transmission System Operators (TSOs) to support overall system optimization
- Support a growing list of customer demands

2. Network investment planning

- Identify systemwide options for capacity provisioning including flexible energy services that help reduce traditional network investment and enable greater market participation

A more sophisticated, intelligent, and digital way of managing the emerging distribution system is crucial for DSOs. The implementation of an Advanced Distribution Management System (ADMS) platform becomes an essential ingredient to a successful future.

What is ADMS?

Intelligent platform for optimal management

ADMS is a comprehensive set of tools consisting of:
- Supervisory Control and Data Acquisition (SCADA) solution for remote control and monitoring of field devices
- Outage Management System (OMS) solution for managing planned and unplanned outage events
- Distribution Management System (DMS) solution with a broad collection of advanced power applications for visualization, planning, monitoring, control, and overall management of the distribution system

In short, ADMS provide the intelligence behind the optimal management of ever-changing distribution grids.

Real-time coordination

ADMS applications optimally coordinate the operations of various dispersed resources in real time to:
- Provide optimal voltage level across the distribution grid with bi-directional power flows
- Set and coordinate properly protection equipment for feeders with high penetration of DER
- Avoid high expenditures in new grid assets by coordinating DER such as PV, EV and energy storage
- Predict future production of variable DER based on weather data output and usage trends and other important factors.
- Identify ways of transferring load during peak energy usage

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A digital solution for DSOs

DSOs cannot rely on manual, paper-driven processes to manage their distribution grids. They need to advance their networks and processes by digitalizing and modernizing ways of performing grid operations.

An ADMS solution can provide DSOs with the ability to withstand the challenges introduced by emerging technologies, and moreover, to transform these challenges into technical and monetary benefits for both DSOs and end customers, by coordinating all the available resources in an optimal fashion.

ADMS benefits

There are many use cases that clearly demonstrate the value ADMS can deliver.

1. Manage voltage fluctuations and reverse power flows

Increasing penetration of DER causes voltage rise reverse power when the local load is low and generation is high. Traditional operations are not designed to handle these issues. These challenges cannot be solved without the coordinated and active control of DER output. ADMS can help identify issues and manage the active control of DERs in a coordinated fashion, and address and avoid the overvoltage and reverse power flow conditions.

2. Coordinate intermittent sources of generation

As the vast majority of DER are fueled by variable energy sources such as sun and wind, sudden loss of significant amounts of generation (e.g., when clouds pass overhead) can occur. Consequently, this can cause sudden and substantial voltage drops at their points of interconnection. Conversely, when the weather conditions clear, sudden restoration of high amounts of power can produce high voltage rises. These effects can produce highly undesirable voltage fluctuations, and these effects cannot be solved with traditional voltage correction techniques. ADMS can simultaneously use a mix of traditional resources with actively managing smart inverters to absorb or generate reactive power, and in that way successfully mitigate adverse voltage conditions.

3. Enable electric vehicle integration to the grid at scale

The growing popularity of electric vehicles introduces new loading challenges that did not exist in the era of traditional distribution systems. Fast chargers of electric vehicles can easily double the peaks of customers' demand. Moreover, it is difficult to firmly predict the exact periods of charging, and consequently the periods of peak demand. Therefore, without proper observability and management of electric vehicles, their integration into the distribution grids can be extremely challenging. Only if they are properly managed, with an exact awareness of the complete system and its correspondent constraints, can a high penetration of electric vehicles be safely integrated.

4. Optimize existing equipment and limit new capital investments

To avoid and defer new capital investments in grid assets, DSOs are pressured to use existing equipment in an optimal way. Optimal utilization of existing equipment can be achieved through reduction of energy losses, peak shaving, and performing conservation voltage reduction (CVR) techniques. However, classical ways of

achieving these goals by using only traditional resources fail to provide an optimal solution in the new distribution grid environment, especially when the penetration of DER is considerable. This is where the advanced ADMS applications designed to maintain optimal voltage levels by better utilizing existing assets, and more intelligently using a mix of traditional resources along with emerging grid edge technologies like smart inverters, can play a major role in helping DSOs achieve their desired objectives.

5. Support higher levels of customers engagement satisfaction

In the current era, where electrical appliances are used to perform almost every task essential for daily living, customers demand a high level of the power quality and reliability. And customers are increasingly opting for more control over the energy future for sustainability, reliability and cost reasons. To achieve the highest level of customer satisfaction, and proper to offer new energy services, DSOs need to ensure that power delivery is reliable, affordable and supportive of a diverse energy mix. This cannot be successfully performed through traditional manual and often paper-driven processes.

Conclusion

Tremendous energy sector revolution poses substantial challenges for distribution utilities. Traditional paper-driven processes for managing formerly-overbuilt distribution grids cannot provide an adequate solution. Properly adapting to these changes requires the deployment of modern digital grid management technologies. An ADMS solution gives network operators a way to cope with increasing complexity and to pave the way for future business success amid ongoing industry disruption.

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